IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of: Mugler et al
Serial Number : 07/723,230
Filed : 06/28/81
For : Three Dimensional Magnetic Resonance Imaging
Group : 265

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PAT. & TRADE MARK OFF.

Commissioner of Patents and Trademarks
Washington, DC 20231

Dear Sir:

INFORMATION DISCLOSURE

U. S. Patent 4,801,884

The Oppelt et al patent discloses an apparatus for identifying nuclear magnetic spectra from spatially selectable regions of an examination subject. Said apparatus supplies pulse signals to the examination subject and the signal emitted by the examination subject in response thereto is evaluated.

U. S. Patent 4,830,012

The Reiderer patent discloses a high speed NMR imaging method and apparatus. Imaging is accomplished by subjecting a body area to a predetermined plurality of applications of short repetition time NMR pulse sequences and constructing an image from data corresponding thereto.

U. S. Patent 4,836,209

The Nishimura patent illustrates a method of NMR imaging of moving material flowing through a slab in a body using variable spatially selected excitation.

U. S. Patent 4,843,321

The Soták patent illustrates a method for volume localized spectra editing of NMR signals produced by metabolites containing coupled spins.

U. S. Patent 4,856,528

The Yang et al patent discloses a computer-implemented arrangement (apparatus and method) for semi-automatically determining from CT from image data the volume of a tumor. A primary application is to determine a tumor volume for patients with hepatoma and primary hepatic cholangiocarcinoma.

U. S. Patent 4,895,157

The Nambu patent discloses a magnetic resonance imaging system, which applies repeated magnetic fields and a high frequency magnetic field in a predetermined sequence according to a phase encoding method to a region including a selected slice of a subject having a varying portion which periodically varies and in which substantially at least two conditions alternately appear, in order to excite a magnetic resonance phenomena in the selected slice. The system then acquires a magnetic resonance signal due to the magnetic resonance phenomena, and obtain magnetic resonance imaging information of the selected slice from the acquired magnetic resonance signal.

U. S. Patent 4,901,019

The Wedeen patent illustrates a method for obtaining images of, e.g., a vascular tree in a shorter than usual time by deliberately undersampling the object, which results in aliasing, and then processing the undersampled data to eliminate the effects of aliasing.

U. S. Patent 4,984,573

The Leunbach patent illustrates a method of generating a magnetic resonance image of a sample comprising introducing into the sample a contrast medium comprising a paramagnetic material having an electron spin resonance transition having a line width of 1 Gauss or less.

U. S. Patent 4,986,272

The Reiderer et al patent discloses a system which acquires data by performing a scan using a spin echo pulse sequence. An image is produced from the acquired data using a 2DFT reconstruction method.

U. S. Patent 4,991,586

The Mueller et al patent illustrates a method for monitoring vascular flow using magnetic resonance signals. A pulse signal is disclosed for operating a magnetic resonance system wherein a slice of the examination subject is disposed perpendicularly to the flow in a vessel under examination such that is first selectively excited.

Manual of Clinical Magnetic Resonance Imaging, (CMRI) by Heiken et al., Raven Press, New York, 1991, Pages 24-39.

This book explains the impetus for the development of rapid imaging techniques which has been primarily twofold: to improve the efficiency of clinical MRI and to decrease artifacts that arise from cardiac, respiratory and other patient motion.

The Fourier Transform and its Applications, 2nd ed., McGraw-Hill, New York, 1978 by RN Bracewell.

This book explains the ideal case for 2D, which assumes the data is not windowed with asmooting function, the integrand is the weighted proton density times a sinc function.

Spin Lattice Relaxation Time Measurements in Two-Dimensional Nuclear Magnetic Resonance Imaging: Corrections for Plane Selection and Pulse Sequence, by B. R. Rosen, I. L. Pykett and T. J. Brady, Journal of Computer Assisted Tomography 8(2):195-199, April, 1984.

This article discloses the axis perpendicular to the image plane, the integrand is the weighted proton density times the slice profile for the image, which is determined by the net effect of the radio frequency (RF) pulse or pulses in the sequence.

Some Factors Involving Slice Shape Which Affect Contrast in Nuclear Magnetic Resonance (NMR) Imaging, by I. R. Young, G. M. Bydder, European Society of Cardiovascular Radiology (Paris) 28, 112-118, 1985.

This article discloses the axis perpendicular to the image plane, the integrand is the weighted proton density times the slice profile for the image, which is determined by the net effect of the radio frequency (RF) pulse or pulses in the sequence.

Variations in Slice Shape and Absorption as Artifacts in the Determination of Tissue Parameters in NMR Imaging, by I. R. Young, D. J. Bryant and J. A. Payne, Magnetic Resonance in Medicine 2, 355-389, 1985.

This article discloses the axis perpendicular to the image plane, the integrand is the weighted proton density times the slice profile for the image, which is determined by the net effect of the radio frequency (RF) pulse or pulses in the sequence.

Effect of Intersection Spacing on MR Image Contrast and Study Time, by J. B. Kneeland, MD, A. Shimakawa, BSEE, F. W. Wehrli, Ph.D., Radialogy, 158:819-822, 1986.

This articles discloses that if multiple 2D slices are acquired by time-multiplexing the acquisitions for different slice positions as is usually done in standard 2D clinical imaging, the profile for a given slices becomes increasingly distorted as the distance between adjacent slices is decreased.

A Stimulated Echo Artifact from Slice Interference in Magnetic Resonance Imaging, by A. P. Crawley and R. M. Henkelman, Med. Phys. 14 (5), Sep/Oct 1987

This articles discloses that if multiple 2D slices are acquired by time-multiplexing the acquisitions for different slice positions as is usually done in standard 2D clinical imaging, the profile for a given slices becomes increasingly distorted as the distance between adjacent slices is decreased.

Effect of Multislice Interference on Image Contrast in T2- and T1- Weighted MR Images, by W. Kucharczyk, A. P. Crawley, W. M. Kelly and R. M. Henkelman, AJNR-9, May/June 1988

This articles discloses that if multiple 2D slices are acquired by time-multiplexing the acquisitions for different slice positions as is usually done in standard 2D clinical imaging, the profile for a given slices becomes increasingly distorted as the distance between adjacent slices is decreased.

Diagnostic Significance of Interslice Gap and Imaging Volume in Body MR Imaging, by B. W. Schwaighofer, K. K. Yu, R. F. Mattrey, AJR 153, September, 1989

This articles discloses that if multiple 2D slices are acquired by time-multiplexing the acquisitions for different slice positions as is usually done in standard 2D clinical imaging, the profile for a given slices becomes increasingly distorted as the distance between adjacent slices is decreased.

Advances in Magnetic Resonance, Academic Press by W.S. Warren, M. Silver, Academic Press, 12, 248, 1988.

This book discloses the cross-talk between closely spaced slices which can be a disadvantage of 2D multislice acquisitions for closely spaced or contiguous slices, but it is noted that a tremendous amount of research effort has been dedicated to optimizing RF inversion, excitation and refocusing profiles to minimize slice-to-slice interference.

Signal-to-Noise Ratio and Section Thickness in Two-dimensional versus Three-dimensional Fourier Transform MR Imaging, by J. Carlson, Ph.D., L. Crooks, Ph.D., D. Ortendahl, Ph.D., D. M. Kramer, Ph.D., L. Kaufman, Ph.D., Radiology 166, 266-270, 1988.

This article discloses that if the slice thickness (packing in the second phase-encoding direction) is large compared to the in-plane resolution, truncation artifacts arising from the sidelobes of the PSF will be significantly worse in the slice direction. This articles also discloses that if trancation artifacts in the third dimension usually become pronounced with slice thicknesses greater than about 2 to 3 mm.

True Three-Dimensional Image Reconstruction by Nuclear Magnetic Resonance Zeugmatography, by C-M Lai and P.C. Lauterbur, Phys. Med. Biol., 1981, Vol. 26. No. 5, 851-856, 1981

This article discloses that three-dimensional volume techniques can provide several advantaes over two-dimensional multislice techniques. The 3D acquisition inherently provides contiguouse slices and the functional form of the slice profile does not change with the spacing between the slices. If the 3D acquisition employs isotrpic, or nearly isotropic, resolution, the volume data set can be reformatted to yield high-resolution contiguous image slices in any arbitrary orientation.

Clinical Relevance of Two Different Nuclear Magnetic Resonance (NMR) Approaches to Imaging of a Low Grade Astrocytoma, by F. S. Buonanno, I. L. Pykett, T. J. Brady, P. Black, P F. J. New, E. P. Richardson, Jr., W. S. Hinshaw, M. Goldman, G. Pohost and J. P. Kistler, Journal of Computer Assisted Tomography, 6(3):529-535, June, 1982

This article discloses that three-dimensional volume techniques can provide several advantaes over two-dimensional multislice techniques. The 3D acquisition inherently provides contiguouse slices and the functional form of the slice profile does not change with the spacing between the slices. If the 3D acquisition employs isotrpic, or nearly isotropic, resolution, the volume data set can be reformatted to yield high-resolution contiguous image slices in any arbitrary orientation.

This article also discloses that in the early 1980's, 3D imaging results ere reported for excised organs and human brains in-vivo. Initial human applications used saturation recovery and inversion recovery sequences, both of which employed 90½ RF pulses for excitation.

True Three-Dimensional Nuclear Magnetic Resonance Neuro-Imaging in Ischemic Stroke: Correlation of NMR, X-ray CT and Pathology, by I. L. Pykett, Ph.D., F. S. Buonanno, M.D., T. J. Brady, M.D. and J. P. Kistler, M.D., Stroke, Vol. 14, No. 2, March-April, 1983.

This article discloses that three-dimensional volume techniques can provide several advantaes over two-dimensional multi-slice techniques. The 3D acquisition inherently provides contiguouse slices and the functional form of the slice profile does not change with the spacing between the slices. If the 3D acquisition employs isotrpic, or nearly isotropic, resolution, the volume data set can be reformatted to yield high-resolution contiguous image slices in any arbitrary orientation.

This article also discloses that in the early 1980's, 3D imaging results ere reported for excised organs and human brains in-vivo. Initial human applications used saturation recovery and inversion recovery sequences, both of which employed 90½ RF pulses for excitation.

Temporamandibular Joint: Multislab, Three-dimensional Fourier Transformation MR Imaging, by R. M. Wilk, D.D.S. and S. E. Harms, M.D., Radiology, Volume 167, Number 3, 861-863, June, 1988.

The article dislocses that there is an intermediate region where a hybrid approach, ultiple 3D volume imaging, is applicable.

FLASH Imaging, Rapid NMR Imaging Using Low Flip-Angle Pulses, by A. Haase, J. Frahm, D. Matthaei, W. Hanicke and K. D. Merboldt, Journal of Magnetic Resonance 67, 258-266, 1986.

This article discloses the introduction in the mid-1980s of the short-TR, partial flip angle gradient-echo sequences such as FLASH.

Very Fast MR Imaging by Field Echoes and Small Angle Excitation, by P. Van Der Meulen, J. P. Groen, J. J. M. Cuppen, Magnetic Resonance Imaging, Volume 3, Number 3, 297-299, 1985.

This article discloses the introduction in the mid-1980s of the short-TR, partial flip angle gradient-echo sequences such as FFE.

Three Second Clinical NMR Images Using a Gradient Recalled Acquisition in a Study State Mode (GRASS)

This article discloses the introduction in the mid-1980s of the short-TR, partial flip angle gradient-echo sequences such as GRASS.

The Application of Steady-State Free Precession in Rapid 2DFT NMR Imaging: FAST and CE-FAST Sequences, by M. Gyngell, Magn Reson Imaging 6, 415-419, 1988.

This article discloses the introduction in the mid-1980s of the short-TR, partial flip angle gradient-echo sequences such as FAST.

FISP - a new fast MRI Sequence, by A. Oppelt, R. Graumann, H. BarfuB, H. Fischer, W. Hartl, W. Schajor, Electromedica 54, 15-18, 1986.

This article discloses the introduction in the mid-1980s of the short-TR, partial flip angle gradient-echo sequences such as FISP.

Rapid Three-Dimensional MR Imaging Using the FLASH Technique by J. Frahm, A. Haase, D. Matthaei, J Comput Assist Tomogr 10, 363-368, 1986.

This article discloses the use of a TR of 15ms and a flip angle of 15½ produced 128^3 image sets of human hands and feet in only 4 minutes.

FLASH: Clinical Three-Dimensional Magnetic Resonance Imaging by V. M. Runge, M. L. Wood, D. M. Kaufman, et al., Radiographics 8, 947, 1988.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the head.

Three-Dimensional Magnetic Resonance Images of the Brain: Application to Neurosurgical Planning by X. Hu., Ph.D., K. K. Tan, Ph. D. et al, J. Neurosurg 72, 433-440, 1990.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the head.

Selective Three-Dimensional MR Imaging of the Spine by G. Gallimore and S. Harms, J Comput Assist Tomogr 11, 124-128, 1987.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the spine.

Spinal MR Imaging: Multiplanar Representation from a Single High Resolution 3D Acquisition by C. S. Sherry, S. E. Harms and W. K. McCroskey, J Comput Assist Tomogr 11, 859-862, 1987.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the spine.

Three-Dimensional Gradient-Recalled MR Imaging as a Screening Tool for the Diagnosis of Cervical Radiculopathy by J. S. Tsuruda, D. Norman, W. Dillon et al., AJR 154, 375-383, 1990.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the spine.

Three-Dimensional MR Imaging of the Knee Using Surface Coils by S. E. Harms and G. Muschler, J Comput Assist Tomogr 10, 773-777, 1986.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the joints.

Fast Three-Dimensional MR Imaging of the Knee: Comparison with Arthroscopy by R. L. Tyrell, K. Gluckert, M. Pathria, M. T. Modic, Radiology 166, 865-872, 1988.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the joints.

MR Imaging of the Knee: Preliminary Results with a 3DFT GRASS Pulse Sequence by C. E. Spritzer, J. B. Vogler, S. Martinez, et al., AJR 150, 597-603, 1988.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the joints.

Meniscal Abnormalities of the Knee: 3DFT fast-scan GRASS MR Imaging by A. M. Hagga, J. W. Froelich, D. O. Hearshen and K. Sadasivan, AJR 150, 1341-1344, 1988.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the joints.

MR Imaging of the Knee: Comparison of Three-Dimensional FISP and Two-Dimensional Spin-Echo Pulse Sequences by S. L. Solomon, W. G. Totty and J. K. Lee, Radiology 173, 739-742, 1989.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the joints.

New Method for Fast MR Imaging of the Knee by S. E. Harms, D. P. Flamig, C. F. Fisher and J. M. Fulmer, Radiology 173, 743-750, 1989.

This article discloses that three-dimensional sequences, dominated by the 3D gradient-echo techniques, have shown promising results for clinical application in the joints.

Fast Field Echo Imaging: An Overview and Contrast Calculation by P. van der Meulen, J. P. Groen, A. M. C. Tinus and G. Bruntink, Magn Reson Imaging 6, 355-368, 1988.

This article discloses the 3D short-TR gradient-echo sequences can be divided into two general categories, those which employ a steady state of only the longitudinal component of the magnetization vector (e.g., FLASH, FFE) and those which employ a steady state of the complete magnetization vector (e.g., GRASS, FAST, FISP). The major practical difference between the two sequence categories is the resulting image contrast properties.

A Comparison of Fast Spin Echo and Gradient Field Echo Sequences by J. A. Tkach and E. M. Haacke, Magn Reson Imaging 6, 373-389, 1988.

This article discloses the 3D short-TR gradient-echo sequences can be divided into two general categories, those which employ a steady state of only the longitudinal component of the magnetization vector (e.g., FLASH, FFE) and those which employ a steady state of the complete magnetization vector (e.g., GRASS, FAST, FISP). The major practical difference between the two sequence categories is the resulting image contrast properties. This article also discloses another class of sequences that have

played a minor role in 3D imaging which are the spin-echo sequences which employ pulse angles other than 90½ for the RF excitation pulse.

Artifacts Due to Residual Magnetization in Three-Dimensional Magnetic Resonance Imaging by M. L. Wood and V. M. Runge, Med Phys 15, 825-831, 1988.

This article discloses the importance of noting that the 3D implementations of the longitudinal steady-state sequences, which are employed if T1-weighted contrast is desired, have been prone to slice-to-slice intensity banding artifacts. This article also dislcoses the various combinations of magnetic field gradients that have been employed in an attempt to eliminate these artifacts.

Transverse Coherence in Rapid FLASH NMR Imaging by J. Frahm, W. Hanicke and K-D Merboldt, J Magn Reson 72, 307-314, 1987.

This article discloses the importance of noting that the 3D implementations of the longitudinal steady-state sequences, which are employed if T1-weighted contrast is desired, have been prone to slice-to-slice intensity banding artifacts.

Optimization of Spoiler Gradients in FLASH MRI by M. L. Wood, M. Silver and V. M. Runge, Magn Reson Imaging 5, 455-463, 1987.

This article discloses the importance of noting that the 3D implementations of the longitudinal steady-state sequences, which are employed if T1-weighted contrast is desired, have been prone to slice-to-slice intensity banding artifacts.

Elimination of Transverse Coherences in FLASH MRI by A. P. Crawley, M. L. Wood and R. M. Henkelman, Magn Reson Med 8, 248-260, 1988.

This article discloses the importance of noting that the 3D implementations of the longitudinal steady-state sequences, which are employed if T1-weighted contrast is desired, have been prone to slice-to-slice intensity banding artifacts. This article also discloses RF spoiling which has been suggested as a method to eliminate the transverse coherence artificats.

Elimination of the Steady State Transverse Magnetization in Short TR Imaging by Y. Zur, P. Bendel, "Book of Abstracts", Society of Magnetic Resonance in Medicine, 6th Annual Meeting, 440, 1987.

This article discloses RF spoiling which has been suggested as a method to eliminate the transverse coherence artificats.

Spoiling of Transverse Coherences without Spoiler Gradients by Y. Zur, M. L. Wood, L. J. Neuringer, "Book of Abstracts", Society of Magnetic Resonance in Medicine, 9th Annual Meeting, 31, 1990.

This article discloses RF spoiling which has been suggested as a method to eliminate the transverse coherence artificats.

An Analysis of RF Phase Shift Spoiling and Its Effect on Contrast by J. B. Murdoch, "Works-in-Progress", Society of Magnetic Resonance in Medicine, 9th Annual Meeting, 1305, 1990.

This article discloses RF spoiling which has been suggested as a method to eliminate the transverse coherence artificats.

UltraFast Spoiled Gradient Recalled (SPGR) Image Acquisition by T. K. F. Foo, M. A. Bernstein, A. E. Holsinger et al, "Works-in-Progress", Society of Magnetic Resonance in Medicine, 9th Annual Meeting, 1308, 1990.

This article discloses that the spoiling technique is now available on the imagers from several commercial vendors and clinical evaluations of the technique.

Rapid 3D Spin-Echo Imaging Using Large Flip Angle Excitation by J. P. Mugler and J. R. Brookeman, Magn Reson Imaging 6(S1), 53, 1988 (abstract)

This article discloses a class of sequences that have played a minor role in 3D imaging which are the spin-echo sequences which employ pulse angles other than 90° for the RF excitation pulse.

Multi-Planar Image Formation Using NMR Spin Echos by P. Mansfield, J Phys C 10, L55, 1977.

This article discloses an imaging which samples the magnetization during a transient entitled the Echo-Planar.

Reduction of MR Imaging Time by the Hybrid Fast-Scan Technique by E. M. Haacke, F. H. Bearden, J. R. Clayton and N. R. Linga NR, Radiology 158, 521-529, 1986.

This article discloses an imaging which samples the magnetization during a transient entitled hybrid imaging.

RARE Imaging: A Fast Imaging Method for Clinical MR by J. Henning, A. Nauerth and H. Friedburg, Magn Reson Med 3, 823-833, 1986.

This article discloses an imaging which samples the magnetization during a transient entitled RARE imaging.

Ultra-High-Speed Inversion Recovery Echo Planar MR Imaging: Technique and Application by M. K. Stehling, R. J. Ordidge and R. Coxon, et al., Radiology 169(P), 377, 1988 (abstract).

This article discloses the use of a contrast preparation followed by a rapid acquisition being demonstrated with echo-planar imaging.

Inversion-Recovery Echo-Planar Imaging (IR-EPI) at 0.5T by M. K. Stehling, R. J. Ordidge, R. Coxon R and P. Mansfield, Magn Reson Med 13, 514-517, 1990.

This article discloses the use of a contrast preparation followed by a rapid acquisition being demonstrated with echo-planar imaging.

Dynamic Contrast-Enhanced Perfusion Studies of the Brain with Snapshot FLASH by D. A. Finelli, B. Kiefer, M. Deimling et al., Radiology 173(P), 42, 1989 (abstract).

This article discloses that the 2D implementations of these magnetization prepared rapid gradient echo (MP RAGE) sequences have shown very promising initial results for perfusion imaging.

Evaluation of First-Pass Cardiac Perfusion with Instant MR Imaging by D. J. Atkinson, D. Burstein and R. R. Edelman, Radiology 173(P), 358, 1989 (abstract).

This article discloses that the 2D implementations of these magnetization prepared rapid gradient echo (MP RAGE) sequences have shown very promising initial results for perfusion imaging.

Cardiac NMR Imaging Using Snapshot FLASH NMR by A. Haase, D. Matthaei, D. Henrich et al., "Book of Abstracts", Society of Magnetic Resonance in Medicine, 8th Annual Meeting, 56, 1989.

This article discloses that the 2D implementations of these magnetization prepared rapid gradient echo (MP RAGE) sequences have shown very promising initial results for cardiac imaging.

Snapshot FLASH Imaging: Cardiac Applications by D. A. Finelli, B. Kiefer, G. Lenz, et al., Radiology 173(P), 275, 1989 (abstract).

This article discloses that the 2D implementations of these magnetization prepared rapid gradient echo (MP RAGE) sequences have shown very promising initial results for cardiac imaging.

"Snapshot-FLASH" Imaging of the Liver by E. E. de Lange, J. P. Mugler III, S. B. Gay et al., Magn Reson Imaging 8(S1), 52, 1990 (abstract).

This article discloses that the 2D implementations of these magnetization prepared rapid gradient echo (MP RAGE) sequences have shown very promising initial results for abdominal imaging.

Breath-Hold Abdominal STIR and T2-Weighted Imaging Using an Interleaved Ultrafast Gradient-Echo Sequence by R. R. Edelman, D. J. Atkinson, B. Wallner B et al., "Works in Progress", Society for Magnetic Resonance Imaging, 8th Annual Meeting, 35, 1990.

This article discloses that the 2D implementations of these magnetization prepared rapid gradient echo (MP RAGE) sequences have shown very promising initial results for abdominal imaging. This article also discloses the original technique of Haase acquires the complete image data in one-shot.

Sequential Inversion Recovery Snapshot-FLASH by U. Bottcher, D. Norris, D. Leibfritz, Magn Reson Imaging 8(S1), 16, 1990 (abstract).

This article discloses the original technique of Haase acquires the complete image data in one-shot.

Improving Image Quality in Snapshot FLASH and 3D MP RAGE Sequences by Employing Reordered Phase Encoding by J. P. Mugler III, T. A. Spraggins, "Works-in-Progress" Society of Magnetic Resonance in Medicine, 9th Annual Meeting, 1310, 1990.

This article discloses that reordered phase encoding can provide an improved point spread funciton and a substantial increase in the CNRs.

Fast Three-Dimensional Snapshot FLASH MR Studies by D. Henrich, A. Haase and D. Matthaei, Radiology 173(P), 289, 1989 (abstract).

This article discloses the straight forward application of the snapshot FLASH technique to a one-shot 3D acquisition results in a measuring time of only a few seconds for a complete 3D data set.

Three-Dimensional Magnetization-Prepared Rapid Gradient-Echo Imaging (3D MP RAGE), J. P. Mugler III and J. R. Brookeman, Magn Reson Med 15, (152-157), 1990.

This article discloses the multi-shot 3D approach of the instant invention.

Inversion Recovery Snapshot FLASH MR Imaging by A. Haase, D. Matthaei, R. Bartkowski et al., J Comput Assist Tomogr 13, 1036-1040, 1989.

This article discloses the snapshot FLASH technique.

Snapshot FLASH MRI, and Applications to T1, T2, and Chemical-Shift Imaging by A. Haase, Magn Reson Med 13, 77-89, 1990.

This article discloses the snapshot FLASH technique.

Ultrafast Measurement of T1- and T2-weighted Images with "SNAPSHOT"-FLASH by B. Kiefer, M. Deimling and D. Finelli, "Book of Abstracts", 8th Annual Meeting of the Society of Magnetic Resonance in Medicine, 1989, p 367.

This article discloses that when the snapshot FLASH technique is implemented on whole-body machins, results are similar to those demonstrated by Haase.

<u>Driven Equilibrium Fourier Transform Spectroscopy. A New Method for Nuclear Magnetic Resonance Signal Enhancement</u> by E. D. Becker, J. A. Ferretti, T. C. Farrar, J Am Chem Soc 91, 7784-7785, 1969.

This article discloses a 90°-delay-180°-delay-90° preparation which can encode T2 contrast in the form of longitudinal magnetization. Depending on the relative phases of the pulses, the encoded magnetization can be placed along the positive z-axis (i.e., a driven equilibrium preparation as in the DEFT technique from NMR spectroscopy).

<u>Cooperative T1 and T2 Effects on Contrast and T2 Sensitivity with Improved Signal to Noise Using a New Driven Inversion Spin Echo (DISE) Sequence</u> by T. E. Conturo, A. H. Beth, R. M. Kessler et al., "Book of Abstracts", Society of Magnetic Resonance in Medicine, 6th Annual Meeting, 807, 1987.

This article discloses a 90°-delay-180°-delay-90° preparation which can encode T2 contrast in the form of longitudinal magnetization. Depending on the relative phases of the pulses, the encoded magnetization can be placed along the negative z-axis (i.e. a driven inversion preparation.

Respiratory Ordered Phase Encoding (ROPE): A Method for Reducing Respiratory Motion Artefacts in MR Imaging by D. R. Bailes, D. J. Gilderdale, G. M. Bydder et al., J Comput Assist Tomogr 9, 835-838, 1985.

This article discloses the MR technique respiratory ordered phase encoding.

Alogorithms for Minimization without Derivatives by R. P. Brent, Prentice Hall, Englewood Cliffs, New Jersey, 1973.

This book discloses the traditional optimizationstrategies such as direction-set methods or conjugate gradient methods.

The State of the Art in Numerical Analysis by D.A.H. Jacobs, Academic Press, London, 1977.

This book discloses the traditional optimizationstrategies such as direction-set methods or conjugate gradient methods.

Very truly yours,

Sheldon H. Parker

Date: March 13, 1992

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JA 3/20/92 #2

GP. 261

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: John P. Mugler et al

Serial No.: 07/ 723,230 Group Art Unit:

Filed: 6/28/91 Examiner:

For: Three Dimensional Magnetic Resonance Imaging

(if applicable) **Batch No.**

Commissioner of Patents and Trademarks
Washington, D.C. 20231

INFORMATION DISCLOSURE STATEMENT

(first page for use during pendency of application)

The following sections are being submitted for this Information Disclosure Statement:

(check sections forming a part of this statement; discard unused sections and number pages consecutively)

1. ☒ Preliminary Statements
2. ☒ Identification Of Time Of Filing
3. ☐ Request For Consideration Of Information Disclosure Statement Submitted After Allowance
4. ☒ Statements With Respect To Listing Of Information
5. ☐ Statements With Respect To Translations Of Non-English Information
6. ☒ Statements With Respect To Copies Of Listed Information Items Accompanying This Statement
7. ☒ Statement Of Non-Possession Of Documents
8. ☒ Concise Explanation Of Listed Information Items

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Valinda M. Allen
(Type or print name of person mailing paper)

Date: 3/13/92

Valinda M. Allen
(Signature of person mailing paper)

1. Preliminary statements

Applicants submit herewith patents, publications or other information of which they are aware, which they believe may be material to the examination of this application and in respect of which there may be a duty to disclose in accordance with 37 CFR 1.56.

While this Information Disclosure Statement may be "material" pursuant to 37 CFR 1.56 it is not intended to constitute an admission that any patent, publication or other information referred to therein is "prior art" for this invention unless specifically designated as such.

In accordance with 37 CFR 1.97(b) the filing of this Information Disclosure Statement shall not be construed to mean that a search has been made or that no other material information as defined in 37 CFR 1.56(a) exists.

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(Text continued on page 6–13)

(Information Disclosure Statement—Section 1 Preliminary Statements **[6-1]**—Page 2 of 9)

2. Identification Of Time Of Filing

This Information Disclosure Statement

(check and complete (a), (b), (c), (d) or (e))

(a) ☐ accompanies the new patent application submitted herewith. 37 CFR 1.97(a)

NOTE: If this item is checked then use FRONT PAGE with Express Mail Certificate of Mailing corresponding to type of mailing for a new case.

(b) ☐ is filed within three months after the filing date of the application or two months after receiving the filing receipt, whichever is later. 37 CFR 1.97(a)

NOTE: Applicants are "encouraged" to file within this time period if the statement is not filed with the application. 37 CFR 1.97(a).

(c) ☒ this Information Disclosure Statement is being submitted as the information was brought to attention.

(d) ☐ is being submitted after notice of allowance and a Request For Consideration Of Information Disclosure Statement Submitted After Allowance (Section 3) is included.

NOTE: Any amendment after the mailing of the notice of allowance may not be made as a matter of right and must be accompanied by a petition fee if made after the issue fee is paid. 37 CFR 1.312.

(e) ☐ is a supplemental Information Disclosure Statement under 37 CFR 1.99

☐ a previous Information Disclosure Statement was filed on ______________

*NOTE: Updating of the Information Disclosure Statement should be submitted to the PTO with reasonable promptness and shall be accompanied by explanations of relevance and by copies of art in accordance with the requirements of the Information Disclosure Statement itself. 37 CFR 1.99. The transmittal **should** include a statement explaining why the information was not earlier transmitted (and this can be done in the space below). If the transmittal is after allowance it **shall** include such an explanation (this is provided for in Request for Consideration of Information Disclosure Statement Submitted After Allowance). MPEP § 609.*

☐ this supplemental Information Disclosure Statement is being submitted as the information was brought to attention

(f) ☐ The art was encountered in the course of the prosecution of the corresponding foreign application(s) in

____

(name(s) of country(ies) and serial number(s))

4. Statements With Respect To Listing Of Information

A list of the patent(s) and/or publication(s) is set forth on the attached (Section 9) one (1) page(s) of Form PTO-1449 (Modified).

NOTE: *In completing PTO-1449 (Modified)it should be kept in mind that 37 CFR 1.98(a) requires that "All United States patents listed should be identified by their patent numbers, patent dates and names of the patentees. Each foreign published application or patent should be cited by identifying the country or office which issued it, the document number and publication date indicated on the document. Each printed publication should be identified by author (if any), title of the publication, pages, date and place of publication."*

The Notice of August 5, 1985 (1057 O.G. 41) States: "Among the information that should be provided on Form PTO-1449 is the date of the citation. In addition, it is helpful if the class and subclass of each citation is provided. It is appreciated that classification information may not be known a the time Form PTO-1449 is prepared. When classification information is not know, draw a line in the boxes under the class and subclass heading adjacent to the citation for which classification information is not known."

NOTE: *"The reference designations "AA", "AB", etc. (referring to Applicants' reference A, Applicants' reference B, etc.) will be used by the Examiner in the same manner as the Examiner's reference designations "A", "B", "C", etc. on Office Action Form PTO-1142." Notice of August 15, 1980 (998 O.G. 5).*

NOTE: *REPRESENTATIVE ITEMS: "When two or more patents or publications considered material are substantially identical, a copy of the representative one may be included in the statement and others merely listed." 37 CFR 1.98(b).*

WARNING: *The Notice of December 23, 1982 (1027 TMOG 7-62) points out. "The final rule states clearly that the publication date indicated on the document should be submitted. This will not serve to preclude a showing of a different, actual publication date. Another purpose of the citation requirement in this section is to permit ready reference to the document from its citation."*

The Notice of August 5, 1985 (1057 O.G. 41) states: "Note that the listing citations on Form PTO-1449 does not raise an irrebuttable presumption that the citation is prior art. A holding by an examiner that any citation on Form PTO-1449 is prior art to claimed subject matter can be rebutted by procedures commonly used to rebut the prior art status of an examiner's citations on Form PTO-892, "Notice of References Cited"."

(complete (a) or (b) if applicable)

(a) ☐ ______________________ is believed to be representative of the following patents or publications:

(b) ☐ ______________________ in the English language is believed to be the equivalent of the following non-English patents or publications:

(Information Disclosure Statement—Section 4 Statements With Respect To Listing Of Information [6-1]—page 4 of 9)

4 of 9

6. Statements With Respect To Copies of Listed Information Items Accompanying This Statement

NOTE: 37 CFR 1.98(a) requires that the information Disclosure Statement shall be accompanied by a copy of each listed patent or publication or other item of information in written form or of a least the portions thereof considered by the person filing the disclosure statement to be pertinent.
37 CFR 1.56(b) states: "Disclosures. . . must be accompanied by a copy of each foreign patent document, non-patent publication, or other non-patent item of information in written form which is being disclosed or by a statement that the copy is not in the possession of the person making the disclosure. . ."
"The portion of a document required to be submitted under § 1.56(b) is the portion which is material to the examination of the application under § 1.56(a)." Notice of November 30, 1983, 49 FR 5-48, January 4, 1984.

There is no assurance that art or other information not submitted with copies of listed items in accordance with the guidelines will be considered by the Examiner. MPEP § 609.

A copy of

- ☐ each
- ☐ none
- ☒ only those listed below

of the items on PTO-1449 (Modified) is supplied herewith:

(indicate if only a portion of a listed item is being supplied)

See attached

"Copies of the Items Supplied herewith"

*NOTE: If each listed item is **not** supplied herewith, complete Section 7, Statement of Non-Possession of Documents, to ensure that Information Disclosure is considered and/or to avoid an Office action.*

(Informaton Disclosure Statement—Section 6 Statement With Respect To Copies Of Listed Information Items Accompanying This Statement [6-1]—page 5 of 9)

7. Statement of Non-Possession Of Documents

With respect to the herein listed foreign patent document(s), non-patent publication(s) or other non-patent item(s) of information in written form which do not accompany this INFORMATION DISCLOSURE STATEMENT I hereby state in accordance with 37 CFR 1.56(b) that

(complete both items (a) and (b) below, if applicable)

(a) by inventor

☐ the document(s) are not in my possession

(b) by attorney

☒ the document(s) are not in my possession

(also complete the following, if applicable)

☒ and I have been informed by the inventor(s) that the document(s) are not in his or her possession

NOTE: If each foreign patent document, non-patent publication or other non-patent item being disclosed is not included with the INFORMATION DISCLOSURE STATEMENT and the above statement of non-possession is not completed, the PTO will notify the applicant to provide the copy or the statement of non-possession and set a term for response. The term for response, when set, may be extended. 37 CFR 1.56(j).

NOTE: 37 CFR 1.56(j) only requires "a statement that a copy is not in the possession of the person making the disclosure." [Emphasis added].

8. Concise Explanation of Listed Information Items

NOTE: 37 CFR 1.98(a) requires that the Information Disclosure Statement **shall** include a "concise explanation" of the relevance of each listed item.

This "concise explanation" may be nothing more than identification of the particular figure or paragraph of the patent or publication which has some relation to the claimed invention. It might be a simple statement pointing to similarities between the listed item and the claimed invention. It is permissable but not necessary to discuss differences between the listed item and the claims. It is thought that the explanation of relevance will be useful to the examiner and should not be significantly burdensome for the applicant to prepare. A statement to the effect that an item is listed because it was cited during the prosecution of a counterpart foreign application and is not considered material to the examination of the U.S. application, is to be considered as satisfying the concise explanation requirement of 37 CFR 1.98(a). MPEP § 609.

There is no assurance that art or other information not submitted with a concise explanation of listed items in accordance with the guidelines will be considered by the Examiner. MPEP § 609.

A concise explanation of the items listed on PTO-1449 (Modified) is:

- ☐ not given
- ☐ given for only some listed item(s)
- ☒ given for each listed item

PTO-1449 (Modified) REFERENCE DESIGNATION — CONCISE EXPLANATION

See attached

Information Disclosure

10. Identification Of Person(s) Making This INFORMATION DISCLOSURE STATEMENT

NOTE: 37 CFR 1.56(b) states: "Disclosures . . . may be made to the Office through an attorney or agent having responsibility for the preparation or prosecution of the application or through an inventor who is acting in his or her own behalf."

The person making this statement is

(check each applicable item (a) and (b))

(a) ☐ the inventor(s) who signs below

____
SIGNATURE OF INVENTOR

____
Type name of inventor who is signing

(b) ☒ the attorney who signs below on the basis of:

(check each applicable item)

- ☐ the information supplied by the inventor(s)
  - ☐ which has been reviewed by the attorney
  - ☐ which has **not** been reviewed by the attorney
- ☒ the information in the attorney's file

Reg. No.: 20,738

Tel. No. (804) 977-6606

____
SIGNATURE OF ATTORNEY

Sheldon H. Parker
Type or print name of attorney

250 West Main St., Suite 100
P.O. Address

Charlottesville Va 22901

(Information Disclosure Statement—Section 10 Identification Of Person(s) Making This Information Disclosure Statement [6-1]—page 9 of 9)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of:		Mugler et al
Serial Number	:	07/723,230
Filed	:	06/28/81
For	:	Three Dimensional Magnetic Resonance Imaging
Group	:	265

Commissioner of Patents and Trademarks
Washington, DC 20231

Dear Sir:

Copies of the Items Supplied herewith

U. S. Patent 4,801,884
U. S. Patent 4,830,012
U. S. Patent 4,836,209
U. S. Patent 4,843,321
U. S. Patent 4,856,528
U. S. Patent 4,895,157
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